

Prospective LCA of a biorefinery concept for production of bulk and fine chemicals

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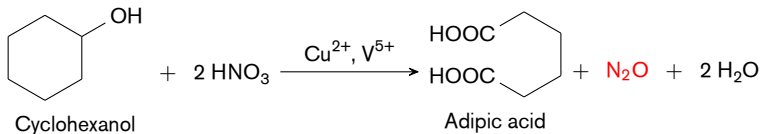
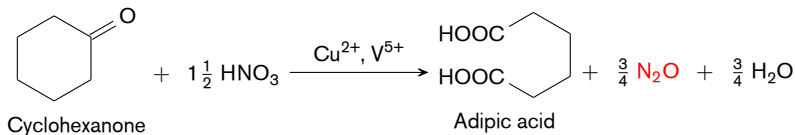


Outline

- 1** The case for bio-based adipic acid production
- 2** Set-up of the systems analysis
- 3** Environmental impacts of the biorefinery concept
- 4** Lessons learned (so far) from the analysis

Fossil-based production of adipic acid

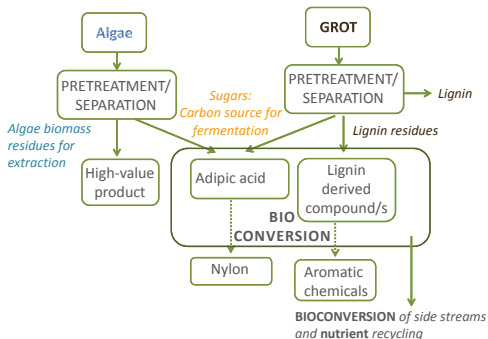
■ Traditional production from fossil resources → KA oil¹



¹ A. Shimizu, K. Tanaka, and M. Fujimori. *Chemosphere - Global Change Science* 2.3-4 (2000), pp. 425–434.

Bio-based production of adipic acid

■ Biorefinery concept for the production of bulk and fine chemicals



- Bulk chemical → Adipic acid², lignin derivative, lignin as a product
- Fine chemical → Lutein

²R. Aryapratama and M. Janssen. *J Clean Prod* 164 (2017), pp. 434–443.

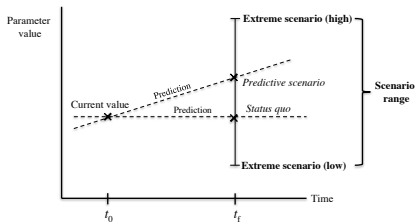
Applying prospective life cycle assessment

- Appropriate methodological choices need to be made³
 - Technology alternatives
 - Foreground system
 - Background system

³R. Arvidsson et al. *J Ind Ecol* (2018), doi: 10.1111/jiec.12690.

Applying prospective life cycle assessment

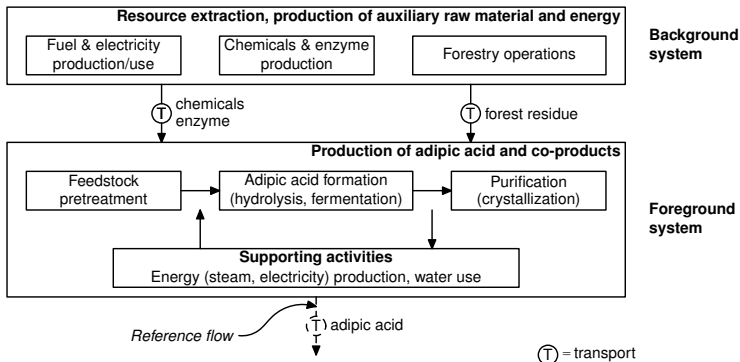
- Appropriate methodological choices need to be made³
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- Predictive scenarios → Based on forecasts or trends
- Scenario ranges → Illustrate potential environmental impact

³R. Arvidsson et al. *J Ind Ecol* (2018), doi: 10.1111/jiec.12690.

Life cycle assessment

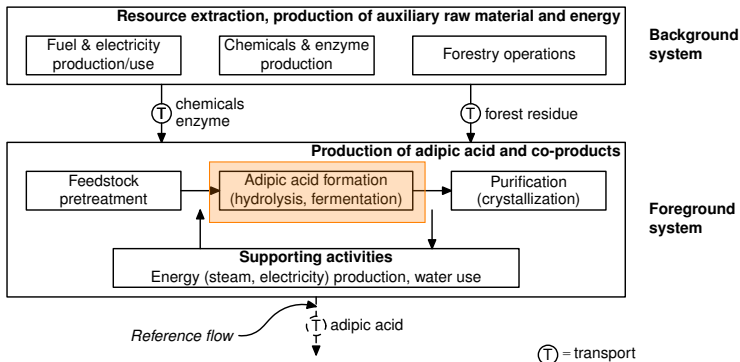


■ Goals

- Guiding technology development
- Future environmental performance of the concept

■ Functional unit → 10 000 t of adipic acid produced

Life cycle assessment

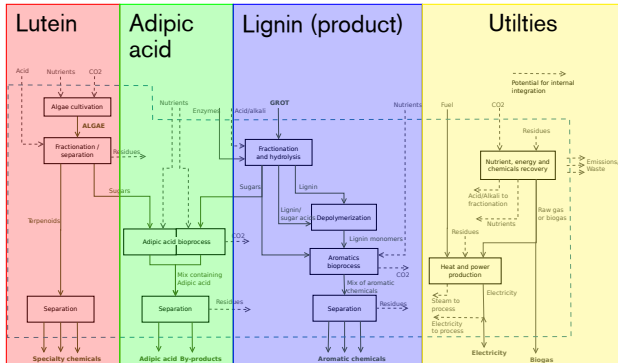


■ Goals

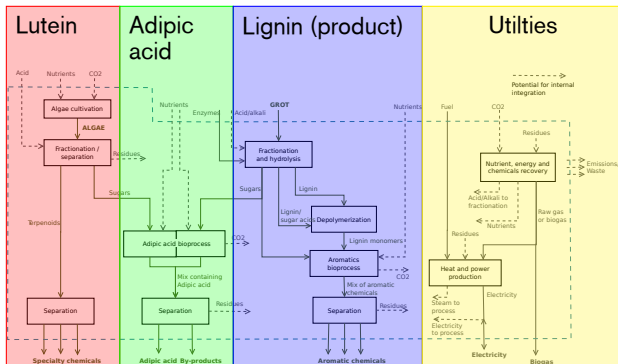
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Integrated biorefinery concept

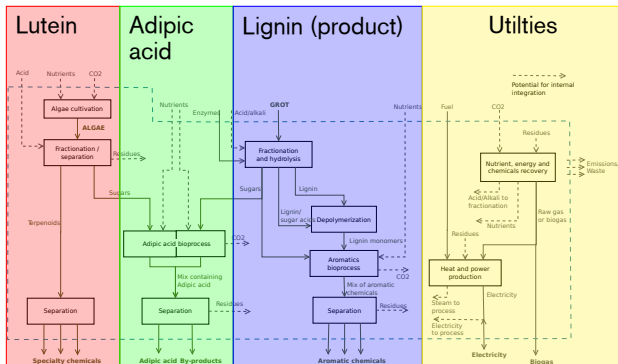


Integrated biorefinery concept



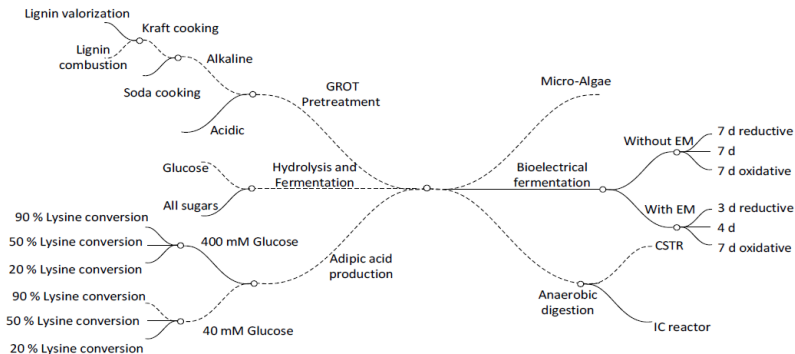
- Alkaline pretreatment (Kraft cooking) with Lignoboost
- Water from anaerobic digestion to conventional WWTP

Integrated biorefinery concept



- Alkaline pretreatment (Kraft cooking) with Lignoboost
- Water from anaerobic digestion to conventional WWTP
- Process integration
 - Pretreatment with adipic acid production → CO₂
 - Adipic acid production with microalgae cultivation → CO₂, water

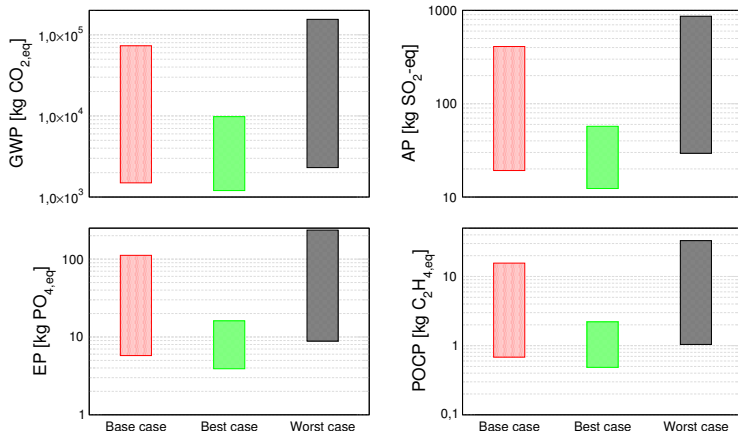
Construction of process alternatives



■ Twelve alternatives were constructed for the assessment

- Lysine conversion → 20 %, 50 % and 90 %
- Sugar concentration → 40 mM and 400 mM
- Sugar conversion → Only glucose, all sugars

Range of current environmental impacts

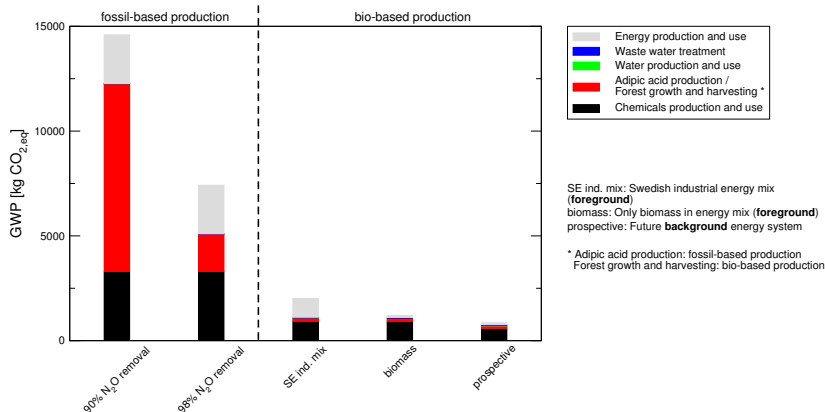


■ Variation due to

- Between alternatives → Foreground system
- Within alternatives → Heating and cooling demands

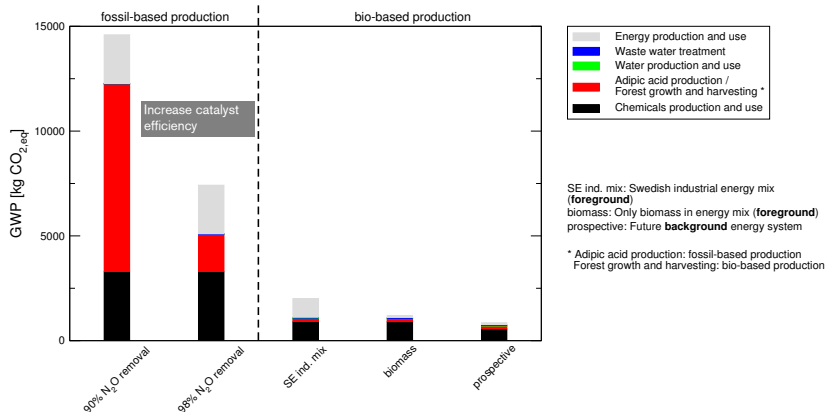
Improvements in global warming potential

From fossil-based to bio-based production (minimum heating and cooling demand)



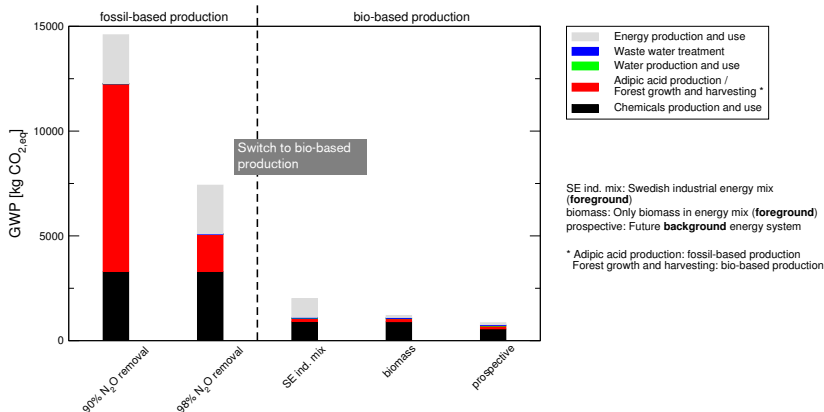
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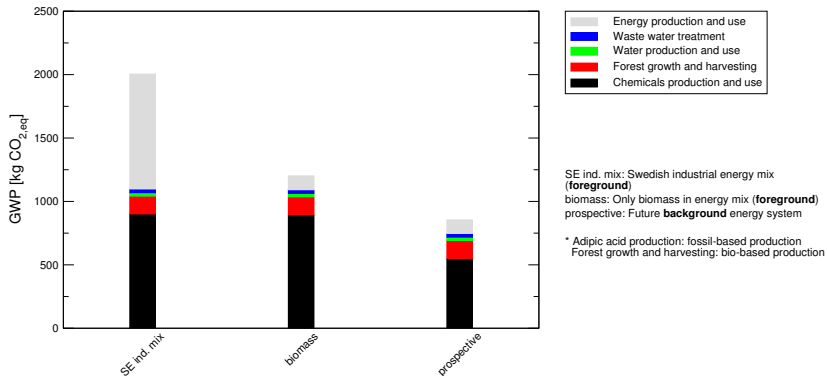
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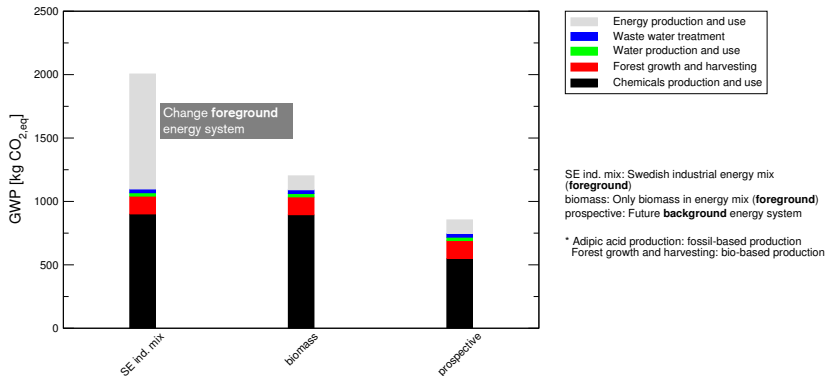
Improvements in global warming potential

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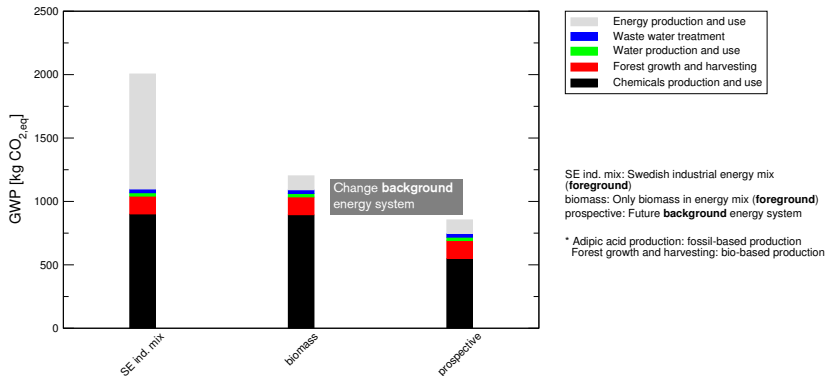
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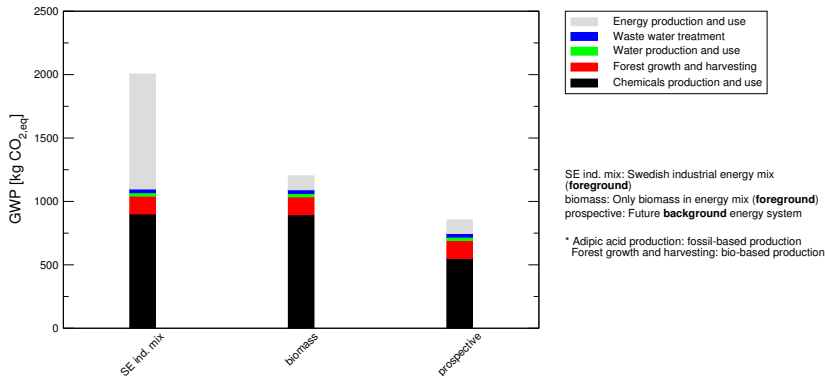
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Bio-based production (minimum heating and cooling demand)



Improvements in global warming potential

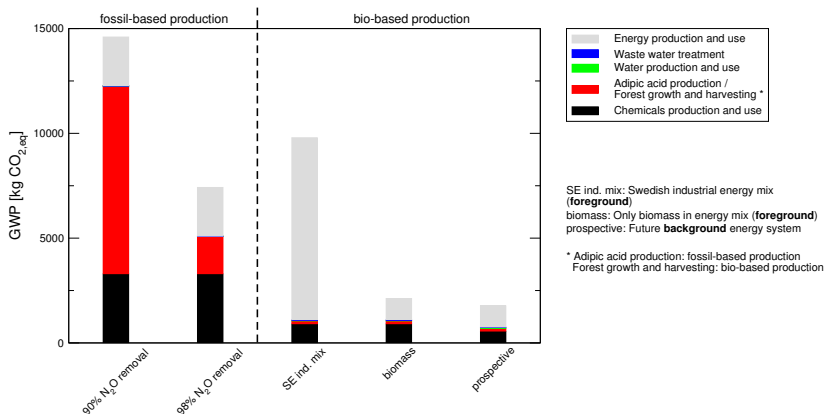
Bio-based production (minimum heating and cooling demand)



- Further improvements in the foreground system are possible
- Change in background energy system mainly affects chemicals production

Improvements in global warming potential

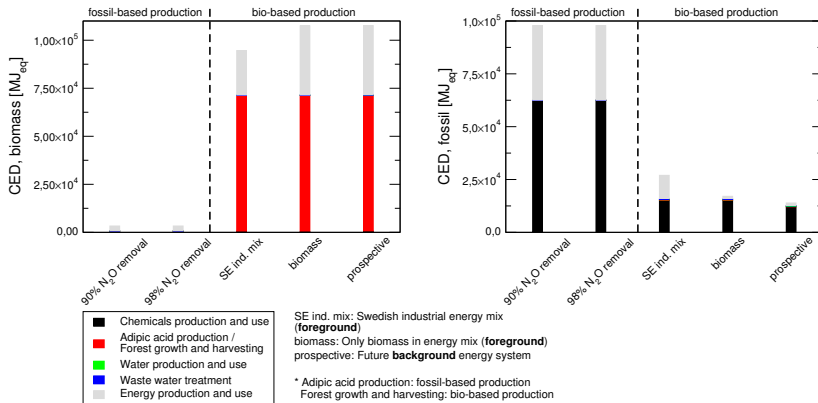
From fossil-based to bio-based production (maximum heating and cooling demand)



- Fossil-based production could be the better option
- Clean foreground energy system is crucial

Changes in energy use

From fossil-based to bio-based production (minimum heating and cooling demand)



- Prospective scenario does not affect renewable energy use
- Changes in environmental impact driven by changes in fossil energy use

Conclusion

■ Technology

- Switch to bio-based production of adipic acid can lower environmental impacts significantly
- Changes in foreground and background both affect environmental performance
 - Clean foreground energy system is crucial
 - Future changes in the background energy system may improve chemicals production and use

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■ Methodology

- Construction of process alternatives helps identify process and environmental risks
- Inventory data generated with detailed process simulation
- Making changes in datasets to model future background energy systems need to be facilitated

THANK YOU
Any questions?

